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The Sensitivity of the United States Environment to Acid Precipitation

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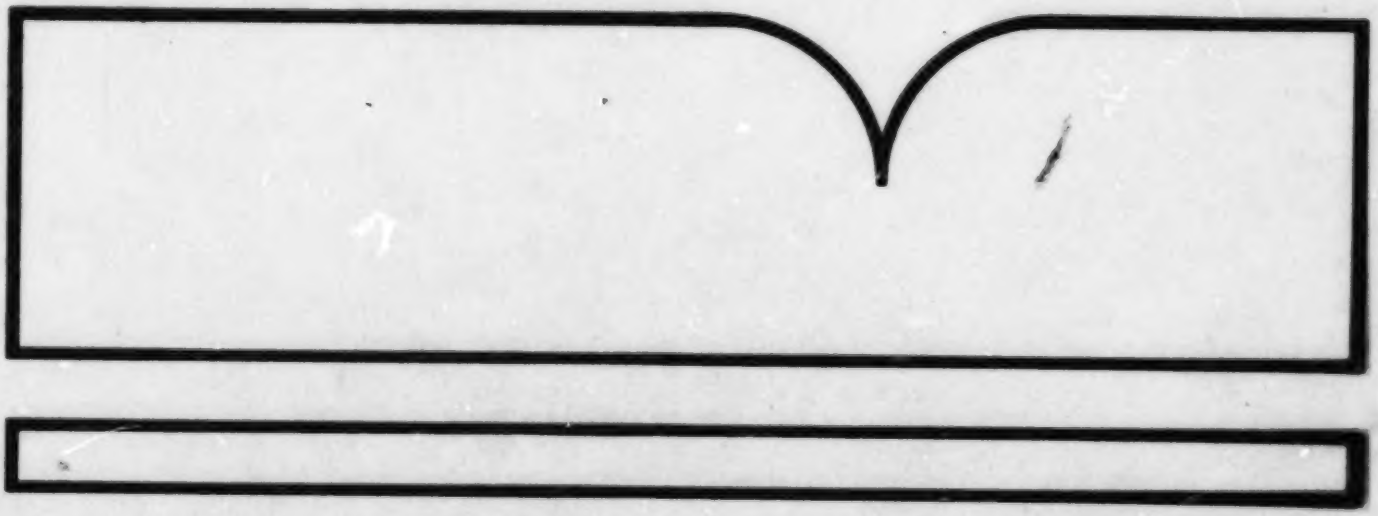

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16. ABSTRACT

There is evidence of the spread of acid precipitation from the northeast to all the states east of the Mississippi River. In view of this a short-term assessment program was initiated by the Environmental Protection Agency in April 1979 to survey the scope of the acid rain problem in the United States. This survey was based primarily on existing information and to a lesser degree, on a series exposure experiments conducted at the EPA experimental farm in Corvallis, Oregon. The field studies examined the effects of acidity on field crops and certain forest processes. These short term findings will be useful in formulating a long-term research effort.

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The sensitivity of the United States environment to acid precipitation

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There is evidence of the spread of acid precipitation from the northeast to all the states of the Mississippi River.

In view of this a short-term assessment program was initiated by the Environmental Protection Agency in April, 1979 to survey the scope of the acid rain problem in the United States. This survey was based primarily on existing information and also to a lesser degree on a series of exposure experiments conducted at the EPA experimental farm in Corvallis, Oregon. The field studies examined the effects of acidity on field crops and certain forest processes. These short term findings, summarized below, will be useful in formulating a long-term research effort.

Bedrock: The northeast and upper Minnesota, Wisconsin, and Michigan are situated largely over poorly buffered bedrock. Most of the lakes there are poorly buffered and thus subject to acidification as described by Hendrey *et al.*[1,2] Sandy coastal regions are also sensitive to acidification. The interrelationship of bedrock, soils and surface waters with respect to acidification and its effects still need to be elucidated.

Soils: Using criteria shown in Table 1, McFee[3] mapped soil sensitivity for the entire eastern United States (Figure 1).

Table 1. Classes of soil sensitivity to acidic precipitation predicted from chemical characteristics of top 25 cm and cation input.

Sensitivity Class	Cation Exchange Capacity meq/100 g	Other Relevant Conditions
Non-sensitive (NS)	Any Value	Free carbonates present or subject to frequent flooding.
	OR	
	> 15.4	None.
Slightly Sensitive (SS)	6.2≤CEC≤15.4	Free carbonates absent; not subject to frequent flooding.
Sensitive (S)	< 6.2	Free carbonates absent; not subject to frequent flooding.

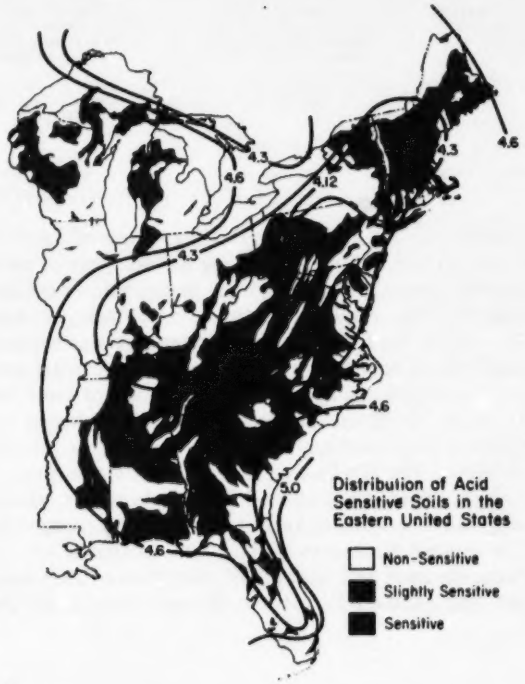

Figure 1. Sensitivity of soils in the eastern United States to acidification. Slightly sensitive soil zones would have more than 10% of their exchangeable cations leached from the upper 25 cm in 25 years if they received the equivalent of 100 cm rainfall per year averaging pH 3.7. Sensitive soils would lose more than 25% of their exchangeable cations under the same conditions. Adapted from McFee.[3]

Superimposed precipitation pH isopleths were modified from Likens *et al.*[7] Sensitive soils include the highly weathered soils of the southeastern United States, the shallow and sloping soils in the Appalachian Highland regions, and the coarse tills of New England. A high percentage of these soils are cultivated with lime and fertilizer masking the effects of acid precipitation. Large areas with sensitive soils are forested, grazed, or unimproved land creating greater sensitivity to prolonged acid loading. Soil chemistry, especially the effects of acidity on chemical species, physiological implications for plant uptake, chemistry of soil leachate, and effect on microbiota require further study. Because of the central role of the soil system in ecosystem processes such as nutrient cycling and the decomposition of organic matter, process studies are needed.

Streams and Fish: Temporal trends in water chemistry covering an 8.5 year span were analyzed from Pennsylvania state stream survey/monitoring data and University records by Arnold *et al.*[4] One-third of the samples showed the streams decreased in pH/alkalinity with corresponding fish losses. Likens *et al.*[7] estimated the average annual pH of precipitation in the state at less than 4.3. Circumstantial evidence

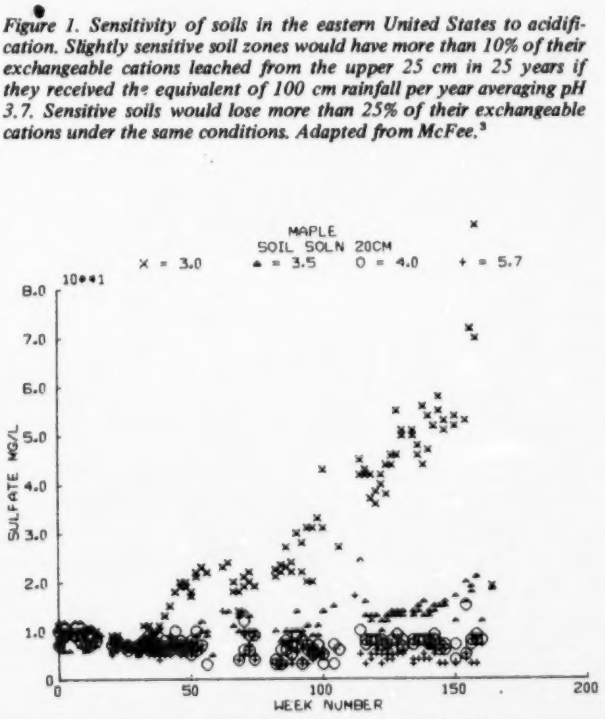

Figure 2. Sulfate concentration of 20 cm depth soil solution vs. time since beginning of treatment. Symbols refer to indicated nominal pH value of rain treatement. From Lee and Weber.[6]

shows damage to Adirondack lakes and Pennsylvania streams may be the result of acid precipitation.

Crops: Lee *et al.*[5] compared relative foliar and/or yield sensitivities of several major farm crops to simulated sulfuric acid rain (pH 3.0, 3.5, or 4.0) or to a control rain. Of the 35 crop varieties examined, the foliage of 31 was injured at pH 3.0, 28 at pH 3.5, and 5 at pH 4.0. A brief summary of the effects on yield is shown in Table 2.

Table 2. Yield results for crop sensitivity to acid rain.

Yield Production	Specific Crops	Crop Groupings
Inhibited	radish, beet, carrot, mustard green, broccoli	dicotyledons (root and leaf crops)
Stimulated	tomato, green pepper, strawberry, alfalfa, orchard grass, timothy	legumes, fruit crops, some monocotyledons (grasses)
Ambiguous	3 crops	
No Measurable Effect	15 crops	grain crops

Forests: Lee and Weber[6] studied the effects of simulated sulfuric acid rain on nutrient cycling in two types of model hardwood forest ecosystems. Forest precipitation percolates through the forest canopy and litter layer producing leachates as the actual input to the soil. Rainwater was regularly collected above and below the canopy, below the litter layer, and at two depths in the soil during a period of more than three years. The litter leachate had consistently higher concentrations of calcium and magnesium, and higher pH, than the acid rain. For the first six months, sulfate absorption by the soil prevented any apparent differences in sulfate, calcium, or magnesium concentrations among plots receiving either acid or control treatments. Sulfate concentrations on plots receiving the most acid rain (pH 3.0) then became increasingly higher than on the other plots until, after three years, they were approximately equal to sulfate concentrations in the rain. Soil solutions corresponding to the pH 3.5 and pH 4.0 treatments responded similarly with a lag time of one year and two years, respectively, after initiation of exposure to acid rain (Figure 2). Increased calcium and magnesium concentrations and lowered pH in 20-cm soil solution occurred simultaneously with increased sulfate concentrations. At a depth of one meter, no acid rain related effects were evident even after 3.5 years exposure to pH 3.0 sulfuric acid rain.

Conclusions: This survey shows an urgent need to monitor streams, watersheds, and fish populations, test perennial crops, orchard crops, and managed forest species over a several year span. An expanded, well funded, multidisciplinary research effort is imperative if human welfare is to be protected.

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